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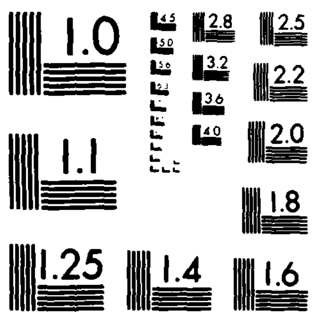

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FOREIGN TECHNOLOGY DIVISION

SMALL CONTINUOUS WAVE (CW) HF CHEMICAL LASER

by

Huang Ruiping and Sun Yizhu

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SMALL CONTINUOUS WAVE (CW) HF CHEMICAL LASER

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Received on 28 May 1982

Abstract: The structure and performances of a small CW HF chemical laser are described. A total of 18 lines from $V=1-0$ and $2-1$ transitions have been observed. The maximum single line output is 900 mW. In single frequency operation, the short-term frequency stability is about 20~30 MHz.

The small continuous wave (CW) HF chemical laser has extensive usages in the diagnosis of the high-power HF chemical laser, dynamic study of laser chemistry, atmospheric transmission, monitoring of atmospheric pollution, determination of characteristics of infrared optical materials, and infrared spectrum. The small CW HF chemical laser (driven with direct-current discharge) has characteristics of simple structure, steady operation, and higher output.

I. Laser Structure

The structure of the laser is basically the same as presented in Literature [1, 2]. Figure 1 shows the schematic diagram of the device.

The discharge tube is a water-cooled glass tube with internal diameter of 25 millimeters and length of 500 millimeters. The anode consists of 8 copper filaments, 2 millimeters in diameter and 200 millimeters in length.

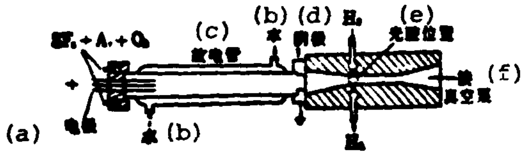

Fig. 1. Schematic diagram of laser (without showing the light chamber).
Key: (a) Electrode; (b) Water; (c) Discharge tube; (d) Cathode; (e) Position of light chamber; (f) Connecting to a vacuum pump.

The cathode is a water-cooled aluminum ring with diameter of the internal hole at 25 millimeters. As acted on by direct-current discharge, the mixing gas SF_6+Ar+O_2 in the direct-current tube produces F atoms. In the mixing zone, a cross-section of 3x150 millimeters is developed. The mixing section is made of bronze, cooled by water. Through small holes (50 each through the upper and lower boards, 0.3 millimeter in diameter), the H_2 gas stream merges vertically into the main gas stream; H_2 reacts with F to produce excited state HF molecules of oscillation. Brewster windows are installed at both sides of the mixing section; the window openings are fitted with a CaF_2 plate. The space in the vicinity of the window opening is washed with N_2 gas in order to remove the fundamental-state HF. Otherwise, the spectral lines of $V=1 \rightarrow 0$ are unable to oscillate. The reaction gas is sucked out with a 70-liters-per-second pump. The speed of the gas stream at the activated zone is approximately 100 meters per second.

The light chamber is a chamber entirely outside of the laser; the light chamber is composed of a total reflection mirror and a grating. The total reflection mirror is a gold-plated mirror with radius of curvature at 1 meter. The grating was made by the Changchun Optics and Precision Instruments Institute with flash wavelength at 2.5 microns and density of engraved lines at 300 lines per millimeter. With measurement, the reflectivity of the polarized light along the direction of the engraved lines perpendicular to the polarization plane can be as high as 88 to 90 percent. Zero grade grating is used as coupling output. The mirror adjustment frame is fixed on two pieces of aluminum alloy plates, which are supported with three indium-steel rods of 20 millimeters in diameter in order to maintain stability of chamber length. The optical axis of the light chamber is situated in the vicinity of the holes for adding H_2. The activated zone is 150 millimeters long; the chamber length is about 35 centimeters. The total reflection mirror is fixed on piezoelectric ceramics; the chamber length can be adjusted by changing the voltage of the piezoelectric ceramics. In order to reduce oscillation of the light chamber, the entire device is placed on an oscillation-free stand cushioned with rubber.

II. Characteristics of Laser

The ordinary parameters for laser operation are as follows: discharge current, 50 to 200 milliamperes; gas flow: 200 milliliters per second for Ar, 50 milliliters per second for SF_6, 10 milliliters per second for O_2, and 100 milliliters per second for H_2. For different transitions, these parameters should be properly adjusted in order to attain the maximum output. Altogether, the authors obtained 18 spectral lines; table 1 lists the power of these corresponding lines. Fluctuation of laser power for high-power lines can be as small as 5 percent, as high as 20 percent for the low-power lines.

Owing to short chamber length and interval of longitudinal mode at 428 megahertz greater than line width of HF (400 megahertz), output of single longitudinal mode can be achieved. By adjusting voltage of piezoelectric ceramics and changing the chamber length, the frequency of spectral lines can be harmonized within the increment line width. Figure 2 shows the output waveform of $F_2(6)$ spectral lines. From Lambert's concave, it is clearly visible that the short-time frequency stability is approximately 20 to 30 megahertz.

The authors thank Wang Hui and Feng Jingke for their assistance.

Table 1. Wave length and power for HF single-line oscillation.

(a) 波长(微米)	对应谱线 (b)	功率(毫瓦) (c)
2.6085	$P_1(3)$	29
2.6398	$P_1(4)$	60
2.6727	$P_1(5)$	80
2.7075	$P_1(6)$	340
2.7441	$P_1(7)$	320
2.7826	$P_1(8)$	110
2.8231	$P_1(9)$	54
2.8657	$P_1(10)$	20
2.7275	$P_2(3)$	2.5
2.7604	$P_2(4)$	15
2.7953	$P_2(5)$	80
2.8318	$P_2(6)$	180
2.8706	$P_2(7)$	500
2.9111	$P_2(8)$	900
2.9539	$P_2(9)$	450
2.9989	$P_2(10)$	160
3.0461	$P_2(11)$	90
3.0987	$P_2(12)$	33

Key: (a) Wavelength (microns); (b) Corresponding spectral lines; (c) Power (milliwatts).

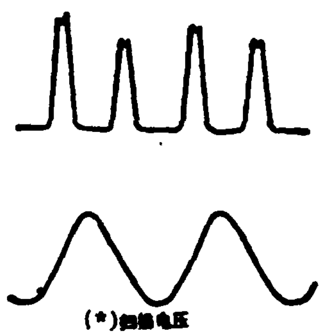

Fig. 2. Frequency scanning waveform of $P_2(6)$ spectral lines.
Key: (*) Scanning voltage.

LITERATURE

[1] J. J. Hinchen; J. Appl. Phys., 1974, 45, 1818.
[2] D. J. Spencer et al.; J. Appl. Phys., 1977, 48, 1210.